Forest and Range Related Energy Industry

California's forests and rangelands provide electrical generation from several sources. These include electricity from hydropower, geothermal, wind, biomass, and solar. Some oil and gas production occurs on these lands, but they are not covered here. Urban wood wastes also contribute to production of electricity to the extent they are buried in landfills and landfill gas is captured and used to help generate electricity.

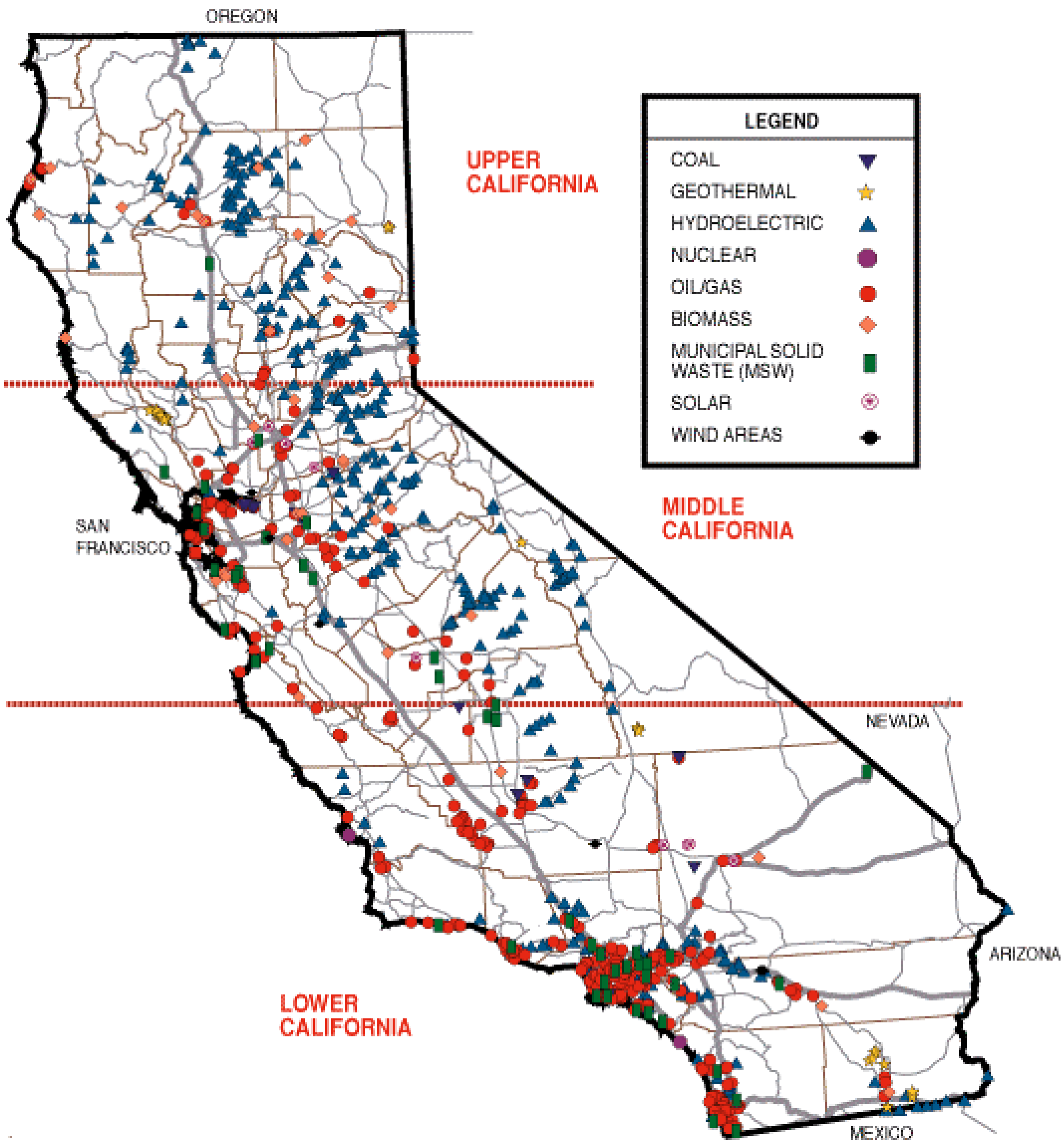
To help quantify the contribution of goods and services from energy resources associated with forests and rangelands, several groups (sub-criteria) of Montreal Process Indicators are used in this section. The sub-criteria include production and consumption Indicators (Indicators 29-34), Investment in Forest Sector (Indicators 38-41) and Employment and Community needs (Indicators 44-47).

The response to these Indicators is summarized by topics on the status of the energy industry as well as contributions from forest and range resources, consumption patterns (demands), production status (supply), current factors affecting the industry (constraints), and opportunities for the forest and range related industry that involve profitability and related factors.

Overview of California's energy resources

California relies on three sources of energy—petroleum, natural gas, and electricity (California Energy Commission (CEC), 2002a). California's electricity system includes over 1,000 power plants that provide power to customers through 27,000 circuit-miles of transmission lines (Figure 1). California's power generation system is owned by numerous entities, with about 44 percent of total generation owned by investor-owned and municipal utilities plus other entities (CEC, 2001a).

Figure 1. California power plants



Source: CEC, 1999a

California has a number of utility service areas that supply electricity. These are shown in Figure 2.

Figure 2. California electric utility service areas

Source: CEC, 2003c

The two largest suppliers for forest and rangeland areas are Pacific Gas and Electric (PG&E) and Southern California Edison (SCE). However, most of the existing power plants once owned by PG&E, San Diego Gas and Electric (SDG&E), and SCE were sold. New plant owners, as well as new plants that will be built in California, are not required to provide electricity to the State.

Since deregulation, the CEC has approved applications for new large power plants that will generate about 20,000 megawatts (MWs). Another 20,000 MWs of proposed capacity is under review by the CEC or may be submitted by developers in the near future.

Forest and range related energy industry structure

About 45 percent of California's electric generation in 2001 came from natural gas. Other sources are listed in Table 1.

Table 1. Gross system electricity production by resource type, statewide, 2001

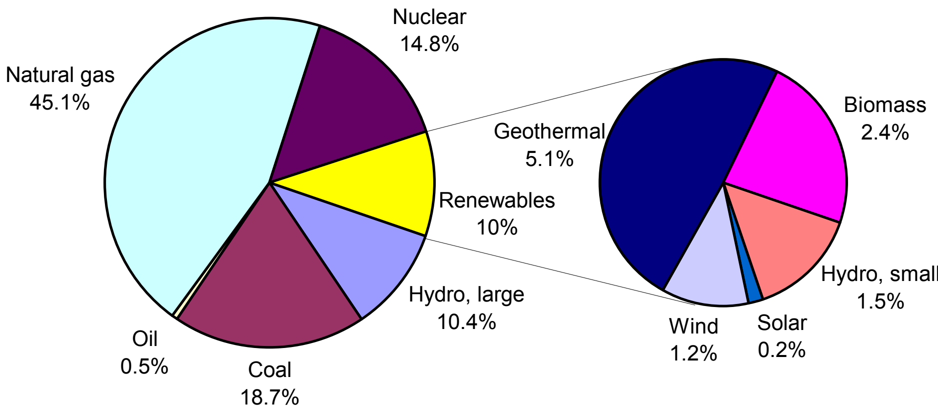
Resource Type	Gigawatt-Hours	Percentage
Hydro	25,005	9.4
Nuclear	33,294	12.62
Coal*	27,636	10.4
Oil	1,328	0.5
Natural Gas	113,145	42.7
Geothermal	13,619	5.1
Biomass & Waste	6,185	2.3
Wind	3,242	1.2
Solar	638	0.2
Northwest imports	6,826	2.6
Southwest imports	33,941	12.8
Total	265,059	100.0

Amount of electricity produced from coal includes out-of-State power plants that are either owned by California utilities or have long term contracts to supply electricity solely to California. This electricity produced from these coal-fired plants is not designated as an "import" even though the plants are located outside the State. The 15 small coal-fired power plants located within California have a name plate capacity of only 550 MWs; less than one percent of total State capacity.

Source: CEC, 2001b

Energy contributions from forests and rangelands are primarily associated with electricity from hydropower, geothermal, wind, and biomass. Large hydro is not considered to be renewable and is defined as any facility employing one or more hydroelectric turbine generators, the sum capacity of which exceeds 30 MWs (CEC, 2001c). In contrast, small hydro (any facility employing one or more hydroelectric turbine generators with a sum capacity of 30 MW or less) is considered renewable. In 2001, renewables contributed 10.5 percent of California's electrical generation. Renewables include small hydro, biomass, geothermal, wind, and solar sources (Figure 3). The most significant contributions come from geothermal and biomass.

Figure 3. Percentage of electric generation by fuel types, statewide, 2001



Source: CEC, 2001b

Significant investments have been made in hydroelectric, geothermal, wind, and biomass generation facilities that draw on resources from forests and rangelands. For example, in the case of biomass, new generating facilities have capital costs in the range of at least $1,250 to $1,750 per kW of capacity. This is a capital cost of $0.025 to $0.045 per kilowatt hour (kWh) of electricity generated. Capital-related costs contribute about 1.4 to 2.8C per kWh (Morris, 1999a).

Value of products from forest and range related energy sectors

According to the U.S. Census Bureau's 1997 Economic Census, the electric power generation, transmission, and distribution sector had an estimated total revenue of 27 billion dollars, an annual payroll of about 3.1 billion dollars, and about 53,000 employees (U.S. Census Bureau, 2002). Except for the number of firms, information for hydro and other electrical generation subsectors was not shown.

Total employment in the California biomass industry is approximated to be 3,600 direct jobs, plus other indirect employment. Total wages paid in California are estimated at approximately $200 million per year. By one estimate, support (indirect) jobs are created at a ratio of almost two to one beyond plant employment, and total employment is equal to 4.9 full-time jobs per MW of net plant generating capacity (Morris, 1999b). In general, power plants provide competitive jobs and good benefits. One estimate of an average annual income for biomass plant workers in 2000 was about $35,000 (Morris, 1999b).

While small compared to other industries, the total economic contribution of energy production related to forest and range resources can be significant locally. This includes factors such as wages and taxes. For example, one estimate indicates that the total tax revenue alone generated from biomass energy is over $47,000 per net MW produced annually (Morris, 1999b). In the case of the biomass industry in California, this would make the total annual tax contribution more than $20 million a year (Morris, 1999b).

In the case of biomass, the economic value of the benefits provided by the existing biomass industry beyond energy are substantial. Biomass utilizes wood wastes that would otherwise be dumped in landfills, burned in the open field, or left in the woods to burn or increase the risk or severity of wildfire. As a result air quality impacts associated with other disposal methods are reduced and threat of wildfire may be lessened. One estimate is that the value of quantifiable benefits is 11.4 cents per kWh of electricity produced from biomass (Morris, 1999b).

Biomass used for energy production may also be associated with the creation of other economic goods such as the production of ethanol or the separation of extractives and natural chemicals associated with production of food flavorings and fragrances.

Findings on consumption of energy

Californians use the least energy per capita of any state. However because of the large and growing population, total electricity use is significant and is projected to increase. California's peak demand for electricity has been growing at an average of about two percent per year over the last decade. Intensive conservation efforts during 1999 and 2000 reduced energy consumption, but the trend is still increasing. During the next decade, however, overall electricity use is expected to grow 19 percent (CEC, 2001a). Past and projected consumption for the electric utility service areas are indicated in Table 2.

Table 2. Historical and projected electricity consumption by utility service area, 1980,1990, 2000 and 2010 (thousands of megawatt-hours)

Year	PG&E	SMUD	SCE	LADWP	SDG&E	Other	Total state
1980	66,197	5,352	59,624	17,669	9,730	8,406	166,979
1990	86,806	8,358	81,673	21,971	14,798	14,432	228,038
2000	102,216	9,775	93,523	24,223	18,707	13,151	261,595
2010	122,656	11,625	113,522	26,906	23,399	14,417	312,525
Cumulative growth (percent)							
1980-1990	31	56	37	24	52	72	37
1990-2000	18	17	15	10	26	-9	15
2000-2010	20	19	21	11	25	10	19
Annual Average (percent)							
1980-1990	2.7	4.6	3.2	2.2	4.3	5.6	3.2
1990-2000	1.6	1.6	1.4	1.0	2.4	-0.9	1.4
2000-2010	1.8	1.7	2.0	1.1	2.3	0.9	1.8

LADWP – Los Angeles Department of Water and Power; PG&E – Pacific Gas and Electric; SCE – Southern California Edison; SDG&E – San Diego Gas and Electric; SMUD – Sacramento Municipal Utility District

Source: CEC, 2001a

Findings on California energy imports and exports

Despite its substantial and abundant generation capacity, California purchases power from sources in the Pacific Northwest, Southwest, Canada, and Mexico. Historically, out-of-State power purchases were generally used to replace more expensive generation produced in California. To transmit power, an extensive network of extra high voltage transmission lines was constructed to access the other regions in the West.

In the last few years, regional electricity markets have shifted, and consumption is increasing to levels above those that formerly met electricity needs at summer peaks. This means a steady reliance on imports. Municipal utilities also depend on imports to meet a significant portion of daily demand for electricity. New generation projects that will substantially increase capacity are under development throughout the west, including California. California does export some electricity, but it is small by comparison to imports.

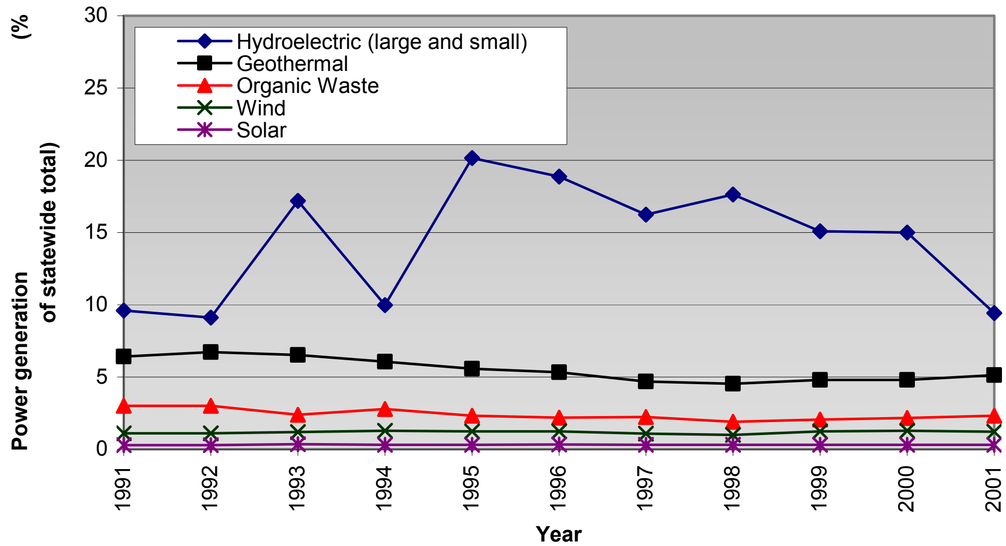
Findings on Energy Prices

Markets for electricity were deregulated in 1998. For the first two years, wholesale electricity prices averaged $33 per megawatt-hour, near the marginal cost of power production. However, for a variety of reasons, California's electricity market experienced volatile price fluctuations during 2000 and 2001. This situation resulted in extremely high electricity prices, less reliability, and large debt accumulated by utility distribution companies. Electricity costs declined during the summer of 2001 and remain at lower levels than 2001 highs.

Findings on production of energy from forest and range-related resources

Hydro (both large and small), geothermal, biomass, and wind energy sources are related to forest and range resources. Over the last two decades, the relative importance of hydro, wind, biomass, and geothermal has varied. However over the last five years, the relative contribution of hydro has declined.

Figure 4. Percentage of statewide annual total power generation for five sources important to forests and rangelands, 1991-2001



Source: CEC, 2002b

Extensive investments have been made in California's electricity producing infrastructure. Geothermal, biomass, wind, and waste to energy (WTE) power plant capacity varies by region.

Table 3. Megawatt production from online power plants by bioregion and plant type, 2001

County	Geothermal	Hydroelectric	Wind	Solar	WTE: Biomass: Agriculture, animal waste, hog fuel, woodwaste	WTE: Biomass: Woodwaste only	WTE: Digester gas, landfill gas and municipal solid waste
Bay Area/Delta	1,122	17	465	0	0	0	42
Central Coast	0	9	0	0	0	12	21
Colorado Desert	475	61	0	0	15	0	0
Modoc	2	26	0	0	0	66	0
Mojave	0	499	368	409	50	0	23
North Coast/Klamath	686	260	0	0	28	64	0
Sacramento Valley	0	3,708	0	3	70	124	6
San Joaquin Valley	0	3,580	982	1	136	1	47
Sierra	277	4,144	0	0	0	126	17
South Coast	0	1,813	0	0	0	0	237
California	2,562	14,117	1,815	413	298	392	393

WTE – waste to energy

Source: CEC, 2002b

Table 4. Percentage of megawatt production from online power plants by bioregion and plant type, 2001

County	Geothermal	Hydroelectric	Wind	Solar	WTE: Biomass: Agriculture, animal waste, hog fuel, woodwaste	WTE: Biomass: Woodwaste only	WTE: Digester gas, landfill gas and municipal solid waste
Bay Area/Delta	44	0	26	0	0	0	11
Central Coast	0	0	0	0	0	3	5
Colorado Desert	19	0	0	0	5	0	0
Modoc	0	0	0	0	0	17	0
Mojave	0	4	20	99	17	0	6
North Coast/Klamath	27	2	0	0	9	16	0
Sacramento Valley	0	26	0	1	23	32	2
San Joaquin Valley	0	25	54	0	45	0	12
Sierra	11	29	0	0	0	32	4
South Coast	0	13	0	0	0	0	60
California	100	100	100	100	100	100	100

MW – megawatt; WTE – waste to energy

Source: CEC, 2002b

In 2001, geothermal, biomass, and wind provided over 90 percent of total renewable energy. About 60 percent of this contribution came just from geothermal. Other significant sources of renewable energy were small hydro, solar, and biogas (gas from landfills and digesters). This does not count contributions from large hydro.

Hydro

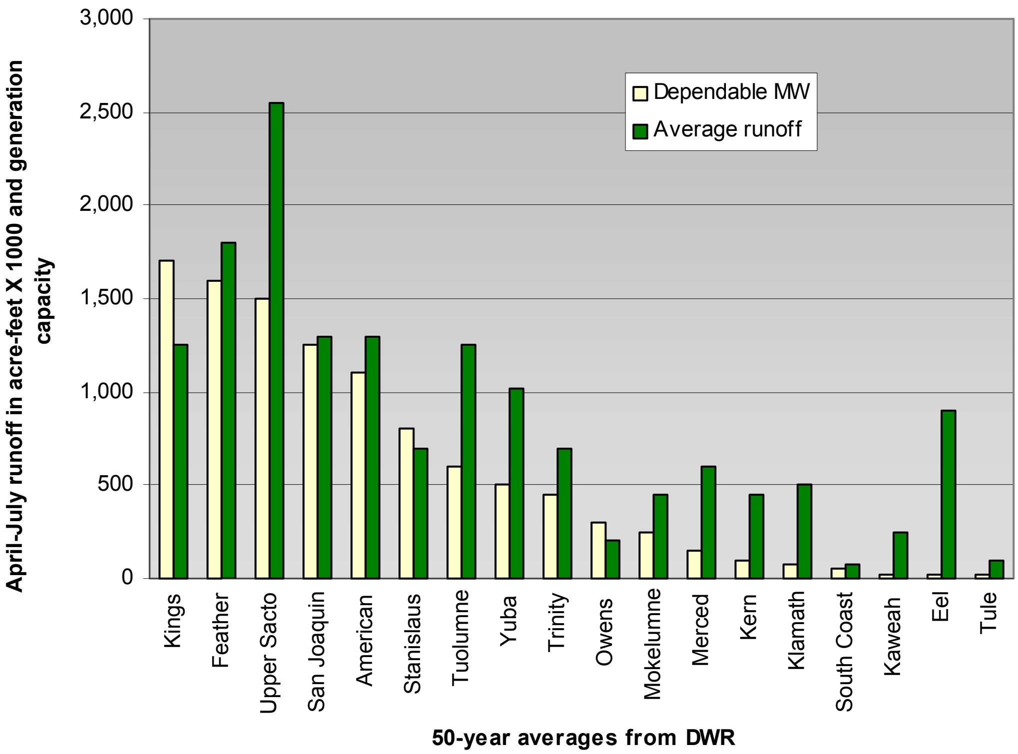
Hydraulic turbines rotate as a result of water moving from a higher to a lower elevation and thus create hydroelectric power (CEC, 2001d). See the online document Hydroelectric Power in California for more information. The water arrives from streams and rivers or is run through man-made facilities such as reservoirs, pipelines, and canals.

Hydro power can be generated by conventional methods that create electricity from water flowing in one direction or by pumped storage methods in which water that is utilized to create electricity can be used again by pumping it back uphill. Conventional hydroelectric facilities can be dams or run-of-river.

Dams increase the water level to make an elevation difference and flow pressure. Run-of-river facilities normally divert water from its natural channel to put it through a turbine, usually returning the water downstream (CEC, 2001d).

From 1983 to 2001 hydroelectric generation in California has averaged 37,345 gigawatts per hour, a figure that is 15.2 percent of the total generation used (including imports) in California (CEC, 2002c). The ability of hydro to contribute to electrical generating capacity is limited by the variability and distribution of rainfall. About 75 percent of the State's rainfall occurs north of Sacramento. Developed hydropower capacity is even more heavily concentrated in this area. Yet 75 percent of consumptive water usage is south of Sacramento. The upper Sacramento and Feather Rivers have the largest average runoffs. The Kings, Feather, and Upper Sacramento have the most reliable generation pattern.

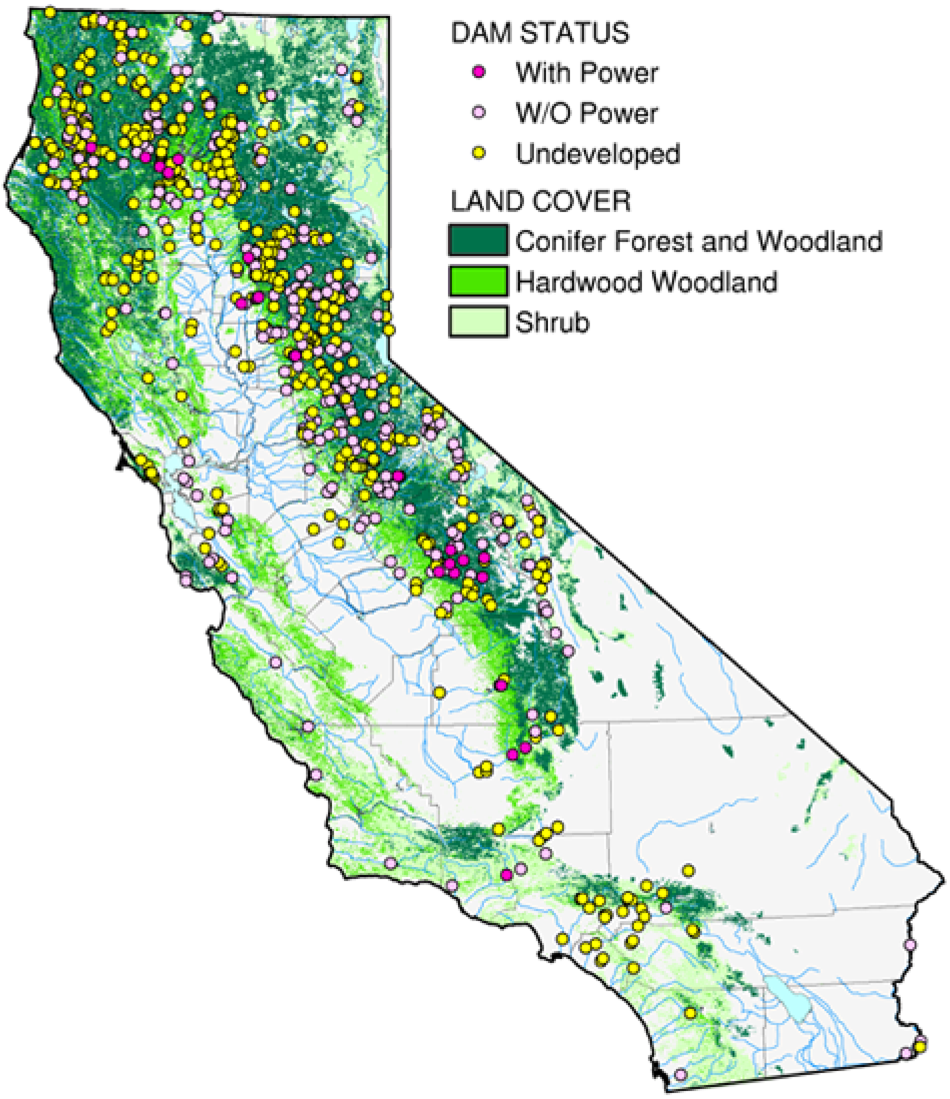
Figure 5. Hydroelectric plant capacity on California rivers



Source: CEC, 2002c

The Federal Energy Regulatory Commission classifies operations using turbines that produce less than 30 MW as "small hydro." There are numerous potential sites on California's rivers that could accommodate small hydro facilities. The California Department of Water Resources (DWR) controls most of the small hydro projects. State restrictions on these kinds of projects are significant both for environmental concerns and water supply issues. In addition to multiple utilities, there are also multiple agencies involved in energy planning. Existing dam sites for 1998 are shown in Figure 6.

Figure 6. Dams with power status



Source: U.S. Department of Energy (DOE), 1998

Geothermal

California now utilizes more than 2,500 MW of geothermal power generating capacity, 40 percent of which is located in the Geysers Resource Area of Northern California. A number of areas have been mapped as having potential for further geothermal development, most of which are on lands classified as forest and rangeland. CEC staff estimates perhaps an additional 3,000 to 4,000 MW of geothermal energy could be developed over the next decade.

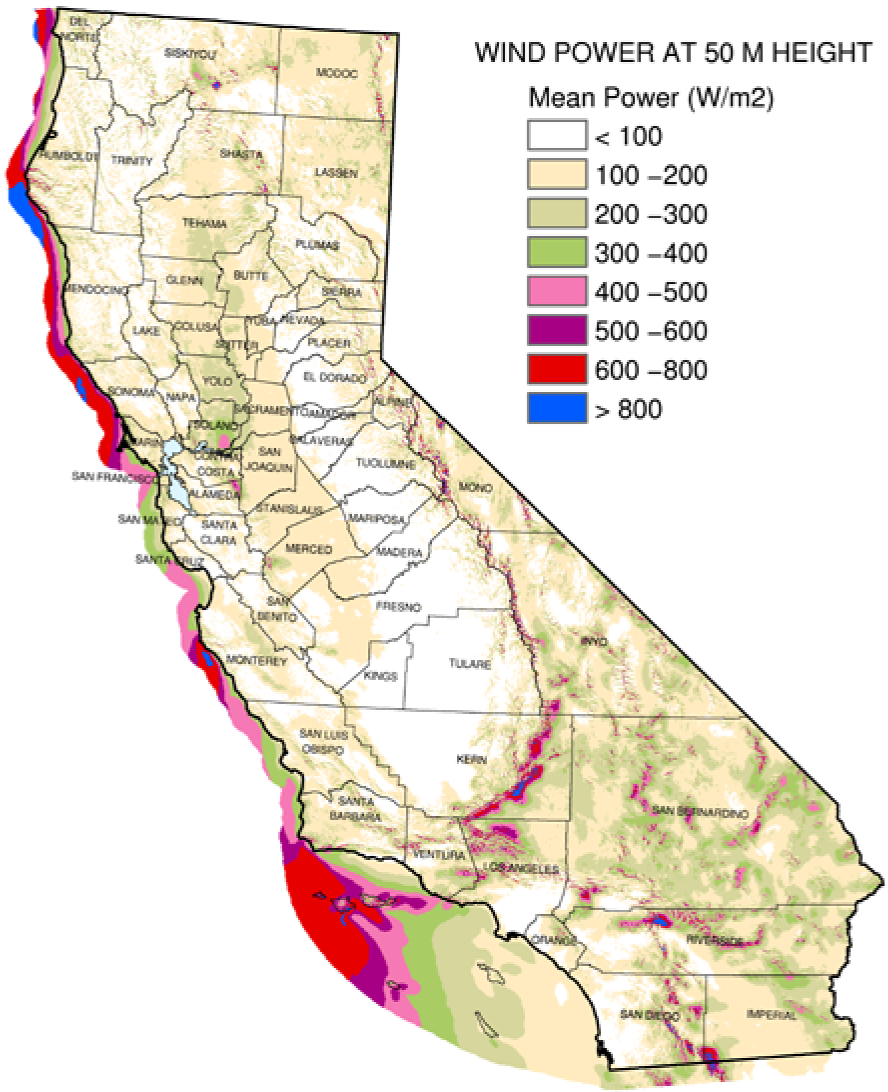
Figure 7. Geothermal power plants and resources

Source: California Department of Conservation, 2000

Wind

Wind-related generation in California now has a capacity of more than 1,800 MW. It is concentrated on wind farms primarily in three areas: Altamont Pass (near Livermore), San Gorgonio Pass (near Palm Springs), and Tehachapi (in Kern County). Small consumer-owned wind projects exist in other parts of the State as well. Another 950 MW is planned for the near future, though the total will be less due to re-powering projects (American Wind Energy Association, 2002).

Figure 8. Wind resource area



Source: CEC, 2003b

Biomass

The term "biomass" refers to vegetative and related organic materials and residues that result from activities in urban, agricultural, forest, and wood processing sources in California. These sources annually generate about 43 million tons of waste. On average, each Californian generates more than one ton of urban waste annually. In addition, an estimated two million tons of chaparral forest types burn annually on California wildlands. Biomass comes from four general sources: agriculture, forest and hardwoods, chaparral, and urban. Estimates of these waste streams vary greatly, but one conservative estimate is listed in Table 5.

Table 5. Gross production and current use of biomass on forests and rangelands (million bone dry tones per year)

Waste source	Gross production	Current use		Excess biomass
		Fuel	Other uses	
Lumber Mill	5.5	1.75	3.25	0
Forest Slash	4.5	0.25		2.5
Forest Thinnings	3.8	0.25		1.4
Chaparral	7.7			0.8
Urban Wood	3.2	1.0	0.5	0.7
Urban Yard	3.9	0.2	0.5	1.2

Source: Springsteen, 2000; CEC, 1999b

The U.S. Forest Service (USFS) has estimated total biomass by species and county as part of the 2002 Resources Planning Act effort. Table 6 lists Statewide totals by species. Public lands contain a greater amount of biomass than private.

Table 6. Live biomass on timberland by ownership and species (millions of oven dry pounds)

Species	Total	USFS	BLM	Other federal	State	County and municipal	Private
Pinyon / Juniper Group	764	0	0	0	0	0	764
Douglas-fir	173,128	74,929	2,803	0	4,040	0	91,356
Port-Orford-cedar	193	193	0	0	0	0	0
Ponderosa pine	84,732	46,354	1,205	0	549	0	36,625
Jeffrey/Coulter pine / big-cone Douglas-fir	61,263	46,097	1,072	0	0	1	14,093
Sugar pine	399,997	198	10,774	0	8,733	1,318	378,974
Western white pine	3,744	3,098	0	0	0	0	645
Fir / Spruce / Mountain Hemlock Group	36,437	5,509	0	0	0	2,912	28,016
White fir	112,692	112,692	0	0	0	0	0
Red fir	90,456	78,674	0	0	0	0	11,782
Mountain hemlock	4,927	4,927	0	0	0	0	0
Lodgepole pine	52,742	46,110	0	423	0	203	6,006
Sitka spruce	1,102	0	0	0	0	0	1,102
Redwood	210,692	93	0	616	25,158	0	184,824
Knobcone pine	2,557	604	0	0	0	0	1,952
Limber pine	62	62	0	0	0	0	0
Whitebark pine	1,297	1,297	0	0	0	0	0
Misc. western softwoods	1,256	1,256	0	0	0	0	0
California mixed conifer	778,608	778,608	0	0	0	0	0
Cottonwood	1,099	1,099	0	0	0	0	0
Cottonwood / willow	99	0	0	0	75	0	25
Aspen	1,969	1,562	0	0	0	406	0
Red alder	7,975	513	0	0	0	0	7,462
Bigleaf maple	2,290	2,290	0	0	0	0	0
Western Oak Group	44,248	0	828	0	456	0	42,964
California black oak	115,357	51,695	1,535	0	307	0	61,820
Oregon white oak	3,793	3,793	0	0	0	0	0
Deciduous oak woodland	1,100	1,100	0	0	0	0	0
Coast live oak	4,115	4,115	0	0	0	0	0
Canyon live oak / interior live oak	146,381	79,777	11,786	0	0	0	54,818
Tanoak	51,150	51,150	0	0	0	0	0
Califonia laurel	121	121	0	0	0	0	0
Giant chinkapin	1	1	0	0	0	0	0
Other Western Hardwoods Group	204,370	2,168	0	0	71	0	202,131
Pacific madrone	49,294	16,277	0	1,858	0	0	31,159
Misc. western hardwood woodlands	1,982	1,982	0	0	0	0	0
Non stocked	4,574	2,880	78	0	0	0	1,616
Total	2,656,565	1,421,226	30,080	2,897	39,388	4,840	1,158,134

BLM – U.S. Bureau of Land Management; USFS – U.S. Forest Service
Source: USFS, 2002

Total tonnage of biomass does not convert directly into biomass that is produced or available for use. The amount available is related to the total production of mill and forest waste, collection and transportation costs, and market conditions. A portion of these available materials is already used. For example, the biomass power industry in California uses about five million bone dry tons (BDTs) of assorted woodwaste and other feedstocks. A portion of the forest biomass is not now commercially utilized and could be utilized in making additional products. For example, the Quincy Library Group (QLG) suggested that 700,000 to 1.1 million BDTs of biomass per year could be garnered from thinnings and timber harvesting slash in three northern California national forests (QLG et al., 1997; CEC, 2001e).

See the online documents Northeastern California Ethanol Manufacturing Feasibility Study and Costs and Benefits of a Biomass-to-Ethanol Production Industry in California for more information.

Forest based biomass is used as fuel to produce electricity. Almost all of this generation takes place at larger scale plants. Biomass plants in California range from 10 MW to 50 MW of electrical generation capacity. Annual fuel requirements vary from 10,000 to 750,000 tons per year for facilities using conventional steam turbine technology (Morris, 2000a).

Throughout the 1980s, sawmill wastes constituted more than 60 percent of the biomass industry's fuel supply (Morris, 2000a). However, this percentage declined significantly as many mills shut down. The usual forms of biomass product for power generation are sawn-log residues from lumber mills and chips created in the woods. Lumber residue is typically much cleaner and easier to process than chips in the forests. Traditionally, chips produced in the woods have served as feeder stock for electricity cogeneration facilities. Cogeneration plants can create power from several sources, typically gas-fired and biomass. A number of cogeneration facilities are adjacent to or part of lumber mills in California.

In places, urban wood wastes also are being used as fuel supply. It is estimated that from 1994 to 1999, 12 to 18 California biomass plants collected between one to two million and one to seven million tons per year of urban wood waste to be used as fuel. Biomass plant capacities and locations were collected by the CEC for 2000. These are indicated in Table 7.

Table 7. Operational and idle biomass power plants, 2000

Project	County	Net MW	MBDTs/yr	Status	Startup	Shutdown
Western Power	Imperial	15.0	122	Idle	1990	1996
Colmac Energy	Riverside	47.0	330	Operating	1992	
Apex Orchard	Kern	5.5	48	Idle	1983	1988
Thermo Ecotek Delano	Tulare	48.0	375	Operating	1991	
Sierra Forest Products	Tulare	9.3	75	Idle	1986	1994
Dinuba Energy	Tulare	11.5	97	Idle	1988	1995
Auberry	Fresno	7.5	70	Idle	1986	1994
Soledad Energy	Monterey	13.5	98	Idle	1990	1994
Thermo Ecotek Mandota	Fresno	25.0	185	Operating	1990	
Rio Bravo Fresno	Fresno	25.0	180	Operating	1989	1994
SJVEP-Madera	Madera	25.0	182	Idle	1990	1995
SJVEP-El Nido	Merced	10.2	88	Idle	1989	1995
SJVEP-Chowchilla II	Madera	10.8	90	Idle	1990	1995
Redwood Food Packing	Stanislaus	4.5	36	Idle	1980	1985
Tracy Biomass	San Joaquin	19.5	150	Operating	1990	
Diamond Walnut	San Joaquin	4.5	35	Operating	1981	
California Cedar Products	San Joaquin	0.8	11	Idle	1984	1991
Jackson Valley, Ione	Amador	18.0	140	Idle	1988	
Fiberboard, Standard	Tuolumne	3.0	27	Idle	1983	1996
Chinese Station	Tuolumne	22.0	174	Operating	1987	
Thermo Ecotek Woodland	Yolo	25.0	200	Operating	1990	
Wheelabrator Martell	Amador	18.0	135	Operating	1987	
Rio Bravo Rocklin	Placer	25.0	180	Operating	1990	1994
Sierra Pacific Lincoln	Placer	8.0	70	Operating	1985	
Wadham Energy	Colusa	26.5	209	Operating	1989	
Georgia Pacific	Mendocino	15.0	119	Operating	1987	
Koppers	Butte	5.5	110	Idle	1984	1984
Ogden Pacific Oroville	Butte	18.0	142	Operating	1986	
Sierra Pacific Loyalton	Sierra	17.0	134	Operating	1990	
Sierra Pacific Quincy	Plumas	25.0	200	Operating	1987	
Collins Pine	Plumas	12.0	90	Operating	1988	
Sierra Pacific Susanville	Lassen	13.0	105	Operating	1985	
Ogden Westwood	Lassen	11.4	90	Operating	1985	
Honey Lake Power	Lassen	30.0	225	Operating	1989	
Big Valley Lumber	Lassen	7.5	59	Operating	1983	
Sierra Pacific Burney	Shasta	17.0	145	Operating	1987	
Odgen Burney	Shasta	10.0	77	Operating	1985	
Burney Forest Products	Shasta	31.0	245	Operating	1990	
Wheelabrator Shasta	Shasta	50.0	380	Operating	1988	
Wheelabrator Hudson	Shasta	6.0	66	Operating	1981	
Sierra Pacific Anderson	Shasta	4.0	60	Operating	1998	
LP Samoe	Humboldt	27.5	300	Idle	1985	1991
Blue Lake	Humboldt	10.0	79	Idle	1985	1999
Pacific Lumber 2	Humboldt	23.0	225	Operating	1988	
Fairhaven Power	Humboldt	17.3	140	Operating	1987	

MBDTs – one thousand bone dry tons
Source: CEC, 2001e

As of 2002, the California Biomass Energy Alliance reports that its 17 member companies operate 36 biomass-fueled power plants in California. Collectively, capacity is about 720 MW of generating capacity at an initial industrial investment of over $2.5 billion (California Biomass Energy Alliance, 2002). About two-thirds of these power plants have power purchase agreements through 2006. Most of the other third have agreements only through 2002 and lack longer-term guarantees. Therefore the sustainability of approximately 20 percent of existing capacity is questionable in the long run.

Growth and decline of California's biomass industry: A significant biomass power industry began to grow in California in 1985 (Morris, 2000a). This growth was based on 10-year contracts that guaranteed the price of power purchase rates. (Pricing of fuel escalation clauses in Standard Offer #4 contracts were based on predicted oil costs of $100 a barrel.) Over time, the industry constructed additional plants, eventually reaching a generation capacity of about 850 MWs (Energy Information Administration, 2001). For a summary history see the online document Biomass Milestones.

This environment increased competition for biomass supplies, raising the price to $55 per BDT of biomass in California in 1992. Eventually, the price of biomass supplies stabilized at about $35 per BDT. In 1994, 37 cogeneration plants in California used 8.5 million tons of biomass. Closures or shutdowns followed beginning in 1995, as cost of renewable feedstock biomass at $0.13 per kWh could not compete with non-renewable fossil fuels such as natural gas at $0.025 per kWh (Shelly and Lubin, 1995). Many plants operate intermittently in response to changing prices for woody biomass products such as in-woods chips, sawdust, orchard wood waste, and urban wood waste.

At its peak, the industry reached a generation capacity of about 850 MWs. However, as the price supports for biomass under the contracts neared an end in 1994-1995, many power plants were closed. By the end of August, 1995, 15 biomass plants with a generation capacity of 500 MWs had been closed through sales or buyouts of their contracts (Morris, 2000b). As of 2001, there were 29 functioning biomass facilities with a generation capacity of about 570 MWs.

There are no plans in progress to construct new conventional biomass plants. The lead-time for bringing such a plant on line is three to four years, meaning that no additional generation will come from new traditional biomass plants before late 2005 or 2006. Smaller units, typically from five kWs to five MW, can also convert biomass to electricity. They are often mobile, require less capital to construct or fuel to run, and can use forest and other wood waste. Various units are being tested in several rural California locations. The CEC, California Department of Forestry and Fire Protection (CDF), and others are looking at the potential of biomass and other renewable energy resources to contribute electricity to meet supply shortages.

Biomass from urban sources primarily takes the form of capturing landfill gas from landfills in some locations. Landfills bring together many wastes, including wood wastes of various sorts. Landfill gas is captured and converted to electricity by gas turbines, boilers, steam turbines, combined cycles, and reciprocating engines.

Californians dispose of about 38 million tons of waste a year in landfills. In 2002, there were a total of 311 active landfills. On these there are 51 landfill gas-to-energy projects in the State (CEC, 2002d). The total electrical generation capacity from the existing landfill gas-to-electricity projects in California is about 211 MW. CEC estimates that perhaps an additional 181 MW could be generated from landfills (CEC, 2002d).

Limits to increased production of energy from forest and range-related resources in California

There are some ongoing issues with the energy infrastructure that may slow development of energy resources related to forests and rangelands. An example is that in some locations, transmission lines or facilities may be insufficient to transmit additional power. In other locations, permit limits or physical constraints may prevent expansion of energy production.

However, investment returns have varied concerning energy production related to resources found on forests and rangelands. Such returns are closely related to the technology used, the cost of fuels or other inputs, and the rates received for electricity. Renewables like wind and biomass have been very sensitive to governmental policies that subsidize or otherwise support development of their electrical generation capacity.

Renewable technologies can cost at least $0.015 or more per KWh to produce electricity than conventional sources such as natural gas. Governmental policies sometimes focus specifically on this cost differential. For example, there is a federal production tax credit, now available to the wind energy and closed-loop biomass power industries. However, it has not been extended to include existing conventional biomass power plants.

To meet critical needs for power, Governor Davis issued Executive Orders (EOs) D-26-01 on February 8, 2001, and D-28-01 on March 7, 2001. Under these orders, the CEC and other government agencies in California are required to expedite the permitting of new emergency peaking projects. As of September 30, 2001, developers had filed applications with the CEC for permits on 11 sites, representing 1,435 MWs of peaking capacity (CEC, 2002e).

In September 2001, the California Consumer Power and Conservation Financing Authority (CPA) signed Letters of Intent with renewable generators for the purchase of 2,400 MW of renewable generation. Later it indicated it would finance or procure an additional 1,250 MW of renewables within the next two years. Governor Davis also signed SB 1078 (SB 1078, Chapter 516, 2002) that requires 20 percent of California's electrical supply mix be met from renewable energy resources by 2017 (called Renewable Portfolio Standard) (Legislative Council of California, 2002). Existing renewable contributions are between eight and nine percent. CEC, in conjunction with the California Public Utilities Commission, is now working to increase procurement of eligible renewable energy resources by at least one percent per year so as to attain the 20 percent standard by 2017.

One potential constraint is that in response to the energy crisis, the DWR negotiated and signed long-term energy contracts in 2001 for the delivery of power to California. Enough contracts were signed to meet the electricity needs of California over the next few years, and some were as long as 20 years in duration. However, having achieved this level of power security, the DWR signed no more contracts for power. This means that developers seeking to build new power plants, including those using renewable resources, would have to take the risk of receiving prices from the spot market (not guaranteed by contract). Most developers have been unwilling to take this risk, so there has not been much new development outside that covered by DWR contracts.

The ability of California to provide for orderly development of its energy resources requires a high degree of coordination and cooperation between multiple utilities and agencies. The State alone has four agencies charged with various aspects of energy planning. These include the CPA, CEC, the California Public Utilities Commission, and the California Independent Systems Operators.

Expanded production of hydro, wind, geothermal, and biomass energy sources are constrained by several general limitations (Table 8):

Table 8. Limitations on expanded production of hydro, wind, geothermal, and biomass

Limitations	Hydro	Wind	Geothermal	Biomass	Solar
Potential sites	Many small, few large	Some general areas, many sites	Some general areas, some sites	Many	Many
Availability of inputs (water, wind, chips)	Severely limited by legal and other requirements	Good in Tehachapi Mountains, limited other	Good in some locations	Harvest and transportation cost limits	Varies by solar intensity and season
Quality of raw materials	Reliable	Periodic	Variable	Variable	Variable
Environmental impacts of production	Regulated	Regulated	Regulated	Regulated	Regulated
Capital investment requirements	Variable, costly for large	Small compared to others	Variable, costly for large	Variable, costly for large	Variable, costly for large
Lead time for added output	Long for large, fast for small	Fast	Moderate	Long, except for starting closed plants	Fast for small, longer for large
Access to grid	Variable	Variable	Variable	Variable	Variable
Price to produce	Variable	Higher than non-renewables	Higher than non-renewables	Higher than non-renewables	Higher than non-renewables
Public tolerance to production	Significant resistance to new large hydro	Some resistance in some locations	Variable	Variable	Variable
Ability to generate additional societal benefits	Except for water storage, limited	Moderate	Moderate	High	Moderate
Agency cooperation needed	High	Moderate	Moderate	High	Moderate

The challenge of biomass: The costs of producing and delivering biomass fuel to power plants are usually higher than its value as a fuel. Approximately one BDT is needed to make one MW of electricity on an hourly basis. The delivered cost is about $35 to $40 dollars per BDT, equivalent to a production cost of about $0.035 to $0.04 per kWh. Current generation cost is about $0.05 per kWh, but the market is paying less. Biomass resources are spread out across the landscape.


Biomass accumulation in a forest

Usually it takes several projects to generate sufficient supply for a biomass plant. Hence, securing fuel supplies for the long-term is a key ingredient for investors prior to building a plant. Another element is transportation costs from forest areas to the plant. These costs depend on both distance and road conditions. They also depend on the availability of labor and equipment to harvest and transport forest materials. However, the closing of biomass plants during the 1990s has diminished the infrastructure available to collect and process biomass.

To varying degrees, the public has expressed concern over the impacts of biomass operations on forest conditions. For example, the public has expressed concern over removal of slash and vegetation. Removal of organic matter reduces the leaf litter, twigs, and other nutrients on the forest floor available to decomposers such as invertebrates, beneficial insects, and fungi. These materials form the basis of forest nutrient cycles and food chains that support local wildlife and plant productivity.

Opportunities for increased production of energy from forest and range-related resources in California

In the last decade, there has been federal and State support for development of additional energy resources, including renewables. This support has exceeded a billion dollars. At least 14 federal laws support the development of biofuels, including the following: 1) Energy Security Act (1978); 2) Energy Tax Act (1978); 3) Gasohol Competition Act (1980); 4) Crude Oil Windfall Profit Tax Act (1980); 5) Energy Security Act (1980); 6) Surface Transportation Assistance Act (1982); 7) Tax Reform Act (1984); 8) Alternative Motor Fuels Act (1988); 9) Omnibus Budget Reconciliation Act (1990); 10) Clean Air Act Amendments (1990); 11) Energy Policy Act (1992); 12) Building Efficient Surface Transportation and Equity Act (1998); and 13) Energy Conservation Reauthorization Act (1998). In addition, the Biomass Research and Development Act was designed to promote research and development leading to the production of biobased industrial products, as well as advancing their availability and widespread use. The Technologies Act focuses on include metabolic engineering of biological systems, catalytic processing, separation technologies, approaches other than metabolic engineering and catalytic conversion, advanced biomass gasification technologies, and related research in advanced turbine and stationary fuel cell technology. The authority this act provides will expire in 2005 (DOE, 2003).

In some cases, support has been given to a specific energy technology, including specific renewables. For example, to foster energy production from wind, the federal tax code was amended in 1992 to provide a Production Tax Credit indexed to inflation and a five-year accelerated depreciation schedule for wind turbines. This credit has been extended on two occasions and will expire at the end of 2003.

The U.S. Department of Agriculture (USDA) and DOE have also supported ongoing research into increased energy efficiency, conservation, production technology, and emerging technologies such as bio-refineries. They have been the source of a variety of initiatives such as the Biomass Research and Development Initiative, the Wind Energy Program, and the Hydropower Program.

California also supports significant energy research. As part of AB 1890 (AB 1078, Chapter 854, 1996) which de-regulated California's electricity system, investor-owned utilities were empowered to collect $540 million from their customers through a Public Goods charge effective through 2001 (Legislative Council of California, 1996). A portion of this money is used to support the Public Interest Energy Research (PIER) Program (including renewables) and the development of renewable resources. See the online document PIER Program (Public Interest Energy Research) for more information (CEC, 2003a). Some of the funding was used to help maintain existing renewable energy capacity and to develop new capacity, including wind turbines. About 1,000 MW of new wind generating capacity will be added under the program.

In 2000, the Reliable Electric Service Investments Act (RESIA) extended the collection of the Public Goods charge until 2012. From these charges, $135 million annually is put into renewable energy development incentives. As of 2002, $62.5 million per year is allocated for public interest research and development efforts. RESIA also required the CEC to create an investment plan that fosters electricity generation from renewable resources. The CEC submitted its recommendations to the Legislature in June 2001.

Ethanol from biomass: Ethanol is alcohol. For the most part, ethanol formulated from biomass in the United States is done by fermenting corn biomass in the Midwest and elsewhere by using sugarcane processing residues. Ethanol can also be produced from cellulosic biomass wastes in California, such as forest, mill, agricultural, and urban wood wastes. Relative to ethanol, a CEC biomass resource assessment estimated that over 8 million BDTs of forest slash and thinnings are available per year (CEC, 1999b).

Ethanol potentially is an important product from biomass in California (CEC, 1999c and 2001e). See the online documents Supply and Cost of Alternatives to MTBE in Gasoline and Costs and Benefits of a Biomass-to-Ethanol Production Industry in California for more information. This is because the federal Clean Air Act mandates that winter gasoline supplies contain an oxygenate to reduce automobile emissions of hydrocarbons, nitrogen oxides, and carbon monoxide. Ethanol can be utilized as this oxygenate. It does not have the toxic properties of methyl tertiary butyl ether (MTBE) which has been the most common oxygenate used for gasoline in California. As a result, Governor Davis has ordered a phaseout of MTBE in California as a gasoline oxygenate.

CEC estimates that additional ethanol demand could range from 580 million to 715 million gallons per year. Co-location of new ethanol plants with existing biomass power plants in California is a possibility. But where there is limited availability of feedstock, tradeoffs between use of biomass for production of electricity and ethanol will require careful planning. This is true with regard to both forest and urban based biomass resources (CEC, 2001e).

For its part, CDF has had a staff person assigned to the advancement of biomass to bioproduct and biofuel conversion processes for more than a decade. The Department has a legislative mandate to further the use of biomass for energy production. A current project is the development of a biomass fueled micro-turbine to produce energy (Washington Ridge Conservation Camp). CDF also has a contract with the PIER Program to develop a GIS system that will identify those areas of California where renewable energy projects (geothermal, wind, photovoltaics, and biomass) are most likely to be successful. This project will be completed in the fall of 2003.

The California Integrated Waste Management Board has been examining how conversion technologies such as gasification and hydrolysis can be used to convert solid waste residuals headed for landfills into feedstocks in order to produce alternative fuels such as ethanol. The source material includes urban wood waste. This aspect is important because under the Integrated Waste Management Act of 1989 (AB 939) all cities and counties must reduce the amount of new landfill waste by 50 percent.

Within California, some Resource Conservation Districts are working with their constituency to develop uses for biomass that would normally be burned or sent to landfills. An example is in Lassen County, where several uses for juniper biomass are being developed. The uses include chips for horse bedding and the production of specialty wood products. Resource Conservation Districts in Ventura, Napa, and Sonoma Counties have also been exploring the use of mulch to control soil erosion in citrus orchards and hillside vineyards.

Other research is aimed at developing information required to increase use of resources such as biomass and wind. One example is a study conducted under a grant from the DOE's Western Regional Biomass Energy Program to promote the development of a green power program using the Lake Tahoe Basin as the fuel source. Another example is the Northern Sierra Biomass study funded under the USDA Rural Technology Development Program and carried out by the Sierra Economic Development District with various partners. For over five years, the CEC has been supporting a biomass project in Anderson

(Shasta County) with subsidies of $0.0135 per kWh to use biomass from wood chips, agricultural residues, and residential garden clippings.

Conclusion

The future role of forest and rangelands in contributing to the production of energy in California is heavily tied to policies developed to implement California's Renewable Portfolio Standard (RPS). Because these lands have solar, wind, geothermal, hydro, and biomass resources, their contribution to energy production is potentially significant. However, since utilities will be looking to meet RPS requirements at the lowest price possible, electricity produced from resources on forest and rangelands will need to be cost competitive with other locations.

For several reasons, the most probable near term options for increased energy production that involve resources tied to forests and rangelands probably are geothermal and wind. Beyond re-opening closed facilities, near-term expansion of biomass plants to generate electricity seems limited. However, when compared to other forest-related resources, biomass in some ways offers the most interesting opportunities for three reasons.

The first reason is that California annually has a net surplus of biomass materials. These materials can be regarded as wastes to be disposed of or as raw materials for other products. For the most part, forest and agricultural biomass wastes are currently disposed of by burning, burying, spreading on the site for natural decomposition, and conversion into other products such as combustion for power and compost. Urban vegetation and wood wastes are mostly put in landfills or converted into other products. The second reason is that the ability of the current system to absorb surplus biomass materials is limited. This can be seen in the ongoing concerns over air quality, water quality, toxics, landfills, and loss of species. As a result, there will be increasing pressure to find alternatives to deal with waste disposal. The third reason is that increased use of biomass can meet multiple goals such as those found in Table 9.

Table 9. Goals met by increased use of biomass

Goal	Gain
Public Safety	Reduction of fuels key to lessening fire control costs and damage to people and resources from wildfire
Strategic defense	Creation of synthetic fuels resulting in reduced dependence on foreign oil for transportation and power
Energy	Use biomass to generate electricity
Job creation	Can provide new jobs that fit California's high tech economy and yield new products
Greenhouse gas reduction	Saves use of fossil fuel, can be used as an oxygenate, emits less methane than burning or decomposition in landfills
Air Quality	Conversion is consistent with cleaner air

The challenge is to make markets and policies work to meet these different objectives. Each biomass waste stream comes with certain characteristics and possibilities. The variety of products is great including compost, raw material for energy and biofuels, and carbon from which sugars can be generated and used for a host of high value synthetic products. In addition, there is a wide range of geographic locations, net environmental impacts, industry conditions, stages of research and commercialization, and institutional barriers. Existing economic and governmental linkages will need to be stretched to link profitable commercial products, willing private investment capital, good accounting of the net social benefits of utilizing biomass, and a variety of institutional and governmental support.

Governmental policy must avoid the tendency to underestimate what it takes to bring some technologies to a commercial stage. The lead time to commercialization may be as much as five to ten years with substantial capital requirement. Private investors are often hesitant to take risks unless the relevant levels of government promote stable land use and fiscal policies. Regulatory compliance costs and delays still may be substantial at implementation. Governments affecting biomass in California have not sent consistent messages in these areas. For their part, local governments' financial resources have been severely reduced in the recent decades. They have little discretionary income to support local economic development or to support design of local biomass-related solutions.

Ultimately, public lands are a key source of biomass supply in California. It is not clear if federal or State agencies will be able to meet environmental goals and still guarantee the stable, long-term supplies requisite to private investment. In this context, public policy will need to squarely address how it will handle removal of material for commercial purposes that is now called "sub-merchantable" by the USFS or "non-commercial" under the Forest Practice Act.

Glossary

biomass: Plant material that can converted into fuel.

BCI: BC International.

BDT: Bone dry ton.

capacity: The maximum amount of electricity that a generating unit, power facility, or utility can produce under specified conditions. Capacity is measured in kilowatts or megawatts.

CDF: California Department of Forestry and Fire Protection.

CEC: California Energy Commission.

cogeneration: Production of heat energy and electrical or mechanical power from the same fuel in the same facility. A typical cogeneration facility produces electricity and steam for industrial process use.

conventional energy: Energy produced from a "conventional power source," as defined in Public Utilities Code Section 2805, that includes power derived from nuclear energy, the operation of a hydropower facility greater than 30 megawatts, or the combustion of fossil fuels with the exception of cogeneration.

CPA: California Consumer Power and Conservation Financing Authority.

digester gas: Gas from the anaerobic digestion of organic wastes.

DOE: U.S. Department of Energy.

DWR: California Department of Water Resources.

electrical corporation: See Section 218 of the Public Utilities Code.

emerging renewable generation technologies: Photovoltaic, solar thermal electric, fuel cell using a renewable fuel, small wind turbine (not more than 50 kilowatts), and other technologies specifically identified by the California Energy Commission as meeting the criteria necessary to be considered emerging under this investment plan.

EO: Executive Order.

facility: See **project**.

fossil fuel: Fuel comprised of hydrocarbon constituents, including coal, petroleum, or natural gas, occurring in and extracted from underground deposits, and mixtures or byproducts of these hydrocarbon constituents.

FRAP: Fire and Resource Assessment Program.

fuel cell: An advanced energy conversion device that combines hydrogen-bearing fuels with air-borne oxygen in an electrochemical reaction to produce electricity very efficiently and with minimal environmental impact.

geothermal: Natural heat from within the earth, captured for production of electric power, space heating, or industrial steam.

gigawatt-hour: One million kilowatt-hours (a typical California household consumes about 500 kWh in an average month).

grid: The electrical transmission and distribution system linking power plants to customers through high power transmission line service.

hydroelectric: A technology that produces electricity from falling water that turns a turbine generator, referred to as hydro. See also **small hydro**.

in-state renewable generation: Biomass, solar thermal, photovoltaic, wind, geothermal, small hydropower of 30 megawatts or less, waste tire, digester gas, landfill gas, and municipal solid waste generation technologies as described in the California Energy Commission's Policy Report on AB 1890 Renewables Funding, including any additions or enhancements, thereto, that are produced in facilities located in this State and placed in operation after September 26, 1996, or that were operational before that date and that are also certified under Section 292.207 of Title 18 of the Code of Federal Regulations as a qualifying small power production facility either located in California or that began selling electricity to a California electrical corporation before September 26, 1996 under a Standard Offer Power Purchase Agreement authorized by the California Public Utilities Commission.

investor-owned utility: A utility that is organized as a tax-paying business, whose properties are managed by representatives elected by shareholders.

IOU: See **investor-owned utility**.

kilowatt: One thousand watts; a unit of measure for the amount of electricity needed to operate given equipment. A typical home using central air conditioning and other equipment might have a demand of 4-6 kilowatts on a hot summer afternoon.

kilowatt-hour: The most commonly-used unit of measure describing the amount of electricity consumed over time. It means one kilowatt of electricity supplied for one hour. A typical California household consumes about 500 kilowatt hours in an average month.

kW: See **kilowatt**.

kWh: See **kilowatt-hour**.

LADWP: Los Angeles Department of Water and Power.

landfill gas: Gas produced by the breakdown of organic matter in a landfill (composed primarily of methane and carbon dioxide) or the technology that uses this gas to produce power.

LFG: See **landfill gas**.

megawatt: One thousand kilowatts; one megawatt is about the amount of power to meet the peak demand of a large hotel.

MTBE: Methyl tertiary butyl ether.

municipal solid waste: Garbage that does not consist primarily of products manufactured from fossil fuels, which can be processed and burned to produce energy.

MW: See **megawatt**.

MSW: See **municipal solid waste**.

PG&E: Pacific Gas and Electric.

photovoltaic: A technology using a semiconductor that converts light directly into electricity.

PIER: Public Interest Energy Research.

project: For the purposes of the New Renewable Resources Account, a group of one or more pieces of generating equipment, and ancillary equipment necessary to attach to the transmission grid, that is unequivocally separable from any other generating equipment or components. Two or more sets of generating equipment that are contiguous, or that share common control or maintenance facilities and schedules and are located within a one mile radius shall constitute a single project. For the purposes of the Emerging Renewable Resources Account, all otherwise eligible generating systems installed during the term of this program at one physical site and serving the electrical needs of all real and personal property located at this site, where a site is a single parcel of real property plus any improvements.

PV: See **photovoltaic**.

QLG: Quincy Library Group.

renewable: A power source other than a conventional power source within the meaning of Section 2805 of the Public Utilities Code, provided that a power source utilizing more than 25 percent fossil fuel may not be included.

RESIA: Reliable Electric Service Investments Act.

SCE: Southern California Edison.

SDG&E: San Diego Gas and Electric.

slash: The unmerchantable material left on a site subsequent to harvesting a timber stand, including tops, limbs, and cull sections.

small hydro: A facility employing one or more hydroelectric turbine generators, the sum capacity of which does not exceed 30 megawatts.

SMUD: Sacramento Municipal Utility District.

solar thermal electric: The conversion of sunlight to heat and its concentration and use to power a generator to produce electricity.

USDA: U.S. Department of Agriculture.

USFS: U.S. Forest Service.

WTE: Waste to energy.

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